Mine Water Treatment during Mine Solids Removal – July 2015
Evaluation of Water Treatment System Discharge Analytical Results

Red and Bonita mine water was treated to enhance solids settling during 2015 cleanout of solids from the mine. The primary objective of the temporary water treatment system was to manage solids generated during the mine investigation and mucking of precipitated solids from the mine adit in preparation for bulkhead construction. Reducing metals concentrations below concentrations discharged historically when the mine was not disturbed by in-mine activity was not targeted. However, the treated water effluent is lower in dissolved metals as shown below. The discharge has been ongoing for many years. Water treatment went as follows:

- Adit discharge flowed freely down the Red and Bonita mine dump.
- Peristaltic pumps were used to inject sodium hydroxide into the water at the base of the mine dump. Each peristaltic could inject a maximum of 1.2 liters per minute (L/min) with 20 feet of tubing. The average sodium hydroxide injection rate was 1 L/min with a maximum of approximately 2 L/min. The target pH range was 6 to 8.
- pH was measured with a Horiba water quality meter placed approximately 10 feet downstream of the sodium hydroxide feed. The monitor was calibrated at least daily.
- Brennfloc was sprinkled into the flowing water downstream of the pH meter using a handheld mill (approximately 3 pounds/hour at 500 gpm mine discharge flow).
- Water cascaded into the ditch along County Road 53 and was diverted to a culvert that carried water under the road and into a baffled lined settling pond.
- Water was pumped from the last cell of the settling pond and discharged to the traditional flow path to Cement Creek. Water was clear to slightly yellow and the turbidity of the discharge ranged from 36 to 42 Nephelometric Turbidity Units (NTU).

SAMPLING AND ANALYSIS

Two samples were collected from the Red and Bonita Mine discharge prior to water treatment and one sample was collected during the third day of treatment. The pre-treatment samples were submitted to EPA's ESAT laboratory under ESAT TDF A-087 and the results are not available as of 8/8/2015.

A sample (RNBEEF01) and duplicate sample (RNBEEF01A) were collected from the discharge pipe of the temporary Red and Bonita treatment pond system during the third day of operation (July 23, 2015). The samples were submitted to TestAmerica of Pleasanton, CA for one day turnaround time analysis. The analytical results are presented in Table 1 along with results of sampling of the Red and Bonita filtration system discharge and Cement Creek downstream of the Red and Bonita inflow during previous years (from Removal Assessment Report, Weston Solutions, December 2014). When analytical results for samples collected during June and July 2015 from the Red and Bonita mine and downstream waters are available, they will be added to the data presentation and this discussion.

Comparison of Duplicate Samples

Comparison of duplicate samples is shown on Table 2. In general, the duplicate sample results are consistent. The dissolved lead concentrations varied by 33 percent. The total aluminum, iron, and lead concentrations varied by more than 25 percent. Variability in total metals concentrations between two samples is expected due to the nonhomogeneous nature of solids in the water column.

Comparison of Total versus Dissolved Concentrations

Comparison of total versus dissolved concentrations of certain metals may provide some indication of the effectiveness of the pond system in removing solids. Table 3 shows the relative percent difference between the total and dissolved concentrations for each sample. The greatest differences were for lead and iron, indicating that these metals were being released from the pond system in light particulates and colloids.

Comparison to 2009-2011 Red and Bonita Discharge Concentrations

In the absence of pre-treatment mine discharge metal concentrations, the analytical results were compared to average metal concentrations from the Red and Bonita Mine from May 2009 through August 2011. The following table shows the average metal concentrations from Red and Bonita Mine discharges from May 2009 through August 2011 and the average concentrations discharged from the treatment system on July 23, 2015.

	Total Metals Concentrations (µg/L)		**Dissolved Metals**	
	2009-2011 Average Mine Discharge	**2015 Settling Pond Discharge**	**2009-2011 Average Mine Discharge**	**2015 Settling Pond Discharge**
Cadmium	35.1	23	35.3	21
Copper	16.7	150	13.0	110
Iron	87,700	18,000	85,400	8200
Lead	49.5	67	6.8	14
Zinc	15,500	7100	15,200	6500

A review of the results indicates the following:

- Total and dissolved cadmium, iron, and zinc concentrations in water discharged from the pond system were lower than average concentrations discharged from the mine from 2009 through 2011. This may indicate that the metals discharged due to solids removal were being retained in the pond and that a portion of the metals previously discharged from the mine during normal discharge conditions are being removed, possibly due to pH adjustment and flocculation.

- Total and dissolved copper and lead concentrations were higher in 2015 pond system discharges than average concentrations discharged from the mine from 2009 through 2011. The results may indicate that copper and lead disturbed during solids removal may not all be captured in the pond system.

- **Both of these conclusions are tentative** due to the lack of recent mine discharge data. The results will be confirmed after comparison to recent, and particularly 2015, mine discharge data.

Comparison to 2013 Discharge and Treatment Discharge

Comparison of the 2015 pond discharge sample results (Table 1) to results from the filtration system used in 2013 may or may not be valid due to variability in Red and Bonita Mine discharge chemistry; however, the comparison shows the following:

- Cadmium concentrations were similar to or lower in 2015 than 2013. There was high variation in cadmium concentrations between the two 2013 samples.

- Copper concentrations were higher in 2015 than in 2013.

- Iron concentrations were lower in 2015 than in 2013. This is a good indicator of the effectiveness of the settling ponds, as iron is a primary component of solids discharged from the mine.

- Lead was not detected in the 2013 samples. The lead detection limits for the 2013 samples was greater than the concentrations detected during 2015.

- Manganese and zinc concentrations were lower in 2015 than in 2013, possibly indicating removal of these metals via pH adjustment. This is not conclusive as the mine discharge concentrations may be different in 2015 than they were in 2013.

TABLE 1
Surface Water Analytical Results

Analyte	RNBEEF01		RNBEEF01A		RBSW02_08092013		RBSW02_08142013		RBSW01_08072013	
	Water Treatment System Effluent		Water Treatment System Effluent Duplicate		Filtration Discharge		Filtration Discharge		Portal Pool Prior to Mine Entries	
	7/23/15		7/23/15		8/9/2013		8/14/2013		8/7/2013	
	Dissolved* (µg/L)	Total (µg/L)	Dissolved* (µg/L)	Total (µg/L)	Dissolved* (µg/L)	Total (µg/L)	Dissolved* (µg/L)	Total (µg/L)	Dissolved (µg/L)	Total (µg/L)
Aluminum	1400	1800	1200	2600	4840 D	5950 D	371 JD	429 JD	3130 D	2800 D
Antimony	10 U	10 U	10 U	10 U	1000 U	1000 U	1000 U	1000 U	1000 U	1000 U
Arsenic	10 U	10 U	10 U	10 U	1000 UJ	1000 U	1000 UJ	1000 U	1000 UJ	1000 U
Barium	50 U	14	50 U	17	50 U	50 U	50 U	50 U	20 JD	21 JD
Beryllium	2 U	2 U	2 U	2 U	50 U	50 U	50 U	50 U	50 U	50 U
Cadmium	21	23	19	23	30.5 JD	31.3 JD	24.2 JD	21 JD	60 U	60 U
Calcium	350,000	350,000	360,000	350,000	425000 D	417000 D	427000 D	417000 D	129000 D	130000 D
Chromium	10 U	10 U	10 U	10 U	50 U	50 U	50 U	50 U	50 U	50 U
Cobalt	51	56	48	47	119 D	108 D	83.7 D	90.6 D	27.4 JD	24.8 JD
Copper	110	150	99	160	50.4 D	76.5 D	30 U	30 U	140 D	144 D
Iron	8200	18,000	7400	25,000	90400 D	93300 D	38000 D	40600 D	15500 D	15700 D
Lead	14	67	10	100	131 JD	290 D	250 U	250 U	250 U	250 U
Magnesium	19,000	21,000	19,000	18,000	26000 D	26000 D	25900 D	25600 D	10100 D	9970 D
Manganese	20,000	21,000	19,000	17,000	33600 D	33300 D	32000 D	31500 D	9140 D	8950 D
Nickel	21	23	19	19	84.6 JD	73 JD	58.8 JD	57.9 JD	100 U	100 U
Potassium	1700	1700	1700	1700	10000 U	10000 U	10000 U	10000 U	10000 U	10000 U
Selenium	20 U	20 U	20 U	20 U	1000 U	917 JD	610 JD	1000 U	1000 U	1000 U
Silver	5 U	5 U	5 U	5 U	100 U	100 U	100 U	100 U	100 U	100 U
Sodium	100,000	100,000	110,000	110,000	7980 JD	8170 JD	79000 D	78600 D	3030 JD	3000 JD
Thallium	10 U	10 U	10 U	10 U	500 U	500 U	500 U	500 U	500 U	500 U
Vanadium	10 U	10 U	10 U	10 U	500 U	500 U	500 U	500 U	500 U	500 U
Zinc	6500	7100	6000	5800	16000 D	15900 D	8740 D	8600 D	5590 D	5430 D

TABLE 2
Total versus Dissolved Treatment System Discharge Sample Results – Samples Collected 7/23/2015

	RNBEEF01	RNBEEF01A	Relative Percent Difference	RNBEEF01	RNBEEF01A	Relative Percent Difference
	Dissolved (µg/L)	Total (µg/L)		Dissolved (µg/L)	Total (µg/L)	
Aluminum	1400	1800	25%	1200	2600	74%
Antimony	10 U	10 U	NA	10 U	10 U	NA
Arsenic	10 U	10 U	NA	10 U	10 U	NA
Barium	50 U	14	NA	50 U	17	NA
Beryllium	2 U	2 U	NA	2 U	2 U	NA
Cadmium	21	23	9%	19	23	19%
Calcium	350,000	350,000	0%	360,000	350,000	3%
Chromium	10 U	10 U	NA	10 U	10 U	NA
Cobalt	51	56	9%	48	47	2%
Copper	110	150	31%	99	160	47%
Iron	8200	18,000	75%	7400	25,000	109%
Lead	14	67	131%	10	100	164%
Magnesium	19,000	21,000	10%	19,000	18,000	5%
Manganese	20,000	21,000	5%	19,000	17,000	11%
Nickel	21	23	9%	19	19	0%
Potassium	1700	1700	0%	1700	1700	0%
Selenium	20 U	20 U	NA	20 U	20 U	NA
Silver	5 U	5 U	NA	5 U	5 U	NA
Sodium	100,000	100,000	0%	110,000	110,000	0%
Thallium	10 U	10 U	NA	10 U	10 U	NA
Vanadium	10 U	10 U	NA	10 U	10 U	NA
Zinc	6500	7100	9%	6000	5800	3%

TABLE 3
Duplicate Treatment System Discharge Sample Results – Samples Collected 7/23/2015

	RNBEEF01	RNBEEF01A	Relative Percent Difference	RNBEEF01	RNBEEF01A	Relative Percent Difference
	Dissolved (µg/L)	Dissolved (µg/L)		Total (µg/L)	Total (µg/L)	
Aluminum	1400	1200	15%	2600	1800	36%
Antimony	10 U	10 U	NA	10 U	10 U	NA
Arsenic	10 U	10 U	NA	10 U	10 U	NA
Barium	50 U	50 U	NA	17	14	19%
Beryllium	2 U	2 U	NA	2 U	2 U	NA
Cadmium	21	19	10%	23	23	0%
Calcium	350,000	360,000	3%	350,000	350,000	0%
Chromium	10 U	10 U	NA	10 U	10 U	NA
Cobalt	51	48	6%	47	56	17%
Copper	110	99	11%	160	150	6%
Iron	8200	7400	10%	25,000	18,000	33%
Lead	14	10	33%	100	67	40%
Magnesium	19,000	19,000	0%	18,000	21,000	15%
Manganese	20,000	19,000	5%	17,000	21,000	21%
Nickel	21	19	10%	19	23	19%
Potassium	1700	1700	0%	1700	1700	0%
Selenium	20 U	20 U	NA	20 U	20 U	NA
Silver	5 U	5 U	NA	5 U	5 U	NA
Sodium	100,000	110,000	10%	110,000	100,000	10%
Thallium	10 U	10 U	NA	10 U	10 U	NA
Vanadium	10 U	10 U	NA	10 U	10 U	NA
Zinc	6500	6000	8%	5800	7100	20%